Wednesday, July 29, 1998
PLENARY SESSION: MEDALIST AWARD TALKS
11:00 a.m. Edmund Burke Theatre

Chair: D. Stöffler

Taylor S. R.*
On the Difficulties of Making Earth-Like Planets

Ivanov B. A.*
The Beauty of Modification in Impact Crater Research (NO ABSTRACT AVAILABLE)

ON THE DIFFICULTIES OF MAKING EARTHLIKE PLANETS. S. R. Taylor, Department of Nuclear Physics, Research School of Physical Sciences, Australian National University, Canberra, ACT 0200, Australia.

Here I examine the series of events that led to the formation and evolution of our planet to examine why the Earth is unique in the solar system. A multitude of factors are involved. These begin with the initial size and angular momentum of the fragment that separated from a molecular cloud,. These are crucial in determining whether a planetary system or a double star develops from the resulting nebula. Another requirement is that there must be an adequate concentration of heavy elements to provide the 2% "rock" and "ice"' components of the original nebula. An essential step in forming rocky planets in the inner nebula is loss of gas and depletion of volatile elements due to early solar activity, which is linked to the mass of the central star.

The lifetime of the gaseous nebula controls the formation of gas giants. In our system, fine timing was needed to form the gas giant Jupiter before the gas in the nebula was depleted. Although Uranus and Neptune eventually formed cores large enough to capture gas, they missed out and ended as ice giants The early formation of Jupiter is responsible for the existence of the asteroid belt (and our supply of meteorites) and the small size of Mars while the gas giant now acts as a gravitational shield for the terrestrial planets.

The Earth and the other inner planets accreted long after the giant planets in a gas-free inner nebula from volatile-depleted planetesimals that were probably already differentiated into metallic cores and silicate mantles. The accumulation of the Earth from such planetesimals was essentially a stochastic process, accounting for the differences among the four rocky inner planets including the startling contrast between those two apparent twins, Earth and Venus. Impact history and accretion of a few more or less planetesimals were apparently crucial. The origin of the Moon by a single massive impact with a body larger than Mars accounts for the obliquity (and its stability) and spin of the Earth in addition to explaining the angular momentum, orbital characteristics and unique composition of the Moon. The hydrosphere and atmosphere of the Earth probably were derived in a random manner from comets as water ice was only stable at around 5 AU.

Plate tectonics, unique among the terrestrial planets, led to the development of the continental crust on the Earth, an essential platform for the evolution of Homo sapiens. Random major impacts have punctuated the geological record, accentuating the directionless course of evolution. Thus a massive asteroidal impact terminated the Cretaceous Period, resulted in the extinction of at least 70% of species living at that time and led to the rise of mammals. This sequence of events that resulted in the formation and evolution of our planet were thus unique within our system. The individual nature of the eight planets is repeated among the 60-odd satellites: no two seem identical.

This survey of our solar system raises the question whether the random sequence of events that led to the formation of the Earth are likely to be repeated in detail elsewhere. Preliminary evidence from the 'new planets' is not reassuring. The discovery of other planetary systems has removed the previous belief that they would consist of a central star surrounded by an inner zone of rocky planets and an outer zone of giant planets beyond a few AU. Jupiter-sized bodies in close orbits around other stars probably formed in a similar manner to our giant planets at several AU from their parent star and subsequently migrated inward becoming stranded in close but stable orbits as "hot Jupiters", when the nebula gas was depleted. Such events would prevent the formation of terrestrial-type planets in such systems.

No Abstract Available.